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ABSTRACT

An attempt is made to discuss current models of information processing, learning, and development, thereby suggesting adequate methodological strategies for research in visual literacy. It is maintained that development is a cumulative process of learning, and that learning and memory are the result of new knowledge, sensations, etc. over a short period of time. Williams nine propositions are examined and recommendations are made for investigating them. It is pointed out that research efforts should be focused on providing evidences of appropriate teaching methods to facilitate visual literacy, and that more sophisticated experimental designs and statistical analysis are badly needed in order to search for scientific evidence in this field. (CH)

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METHODOLOGICAL STRATEGIES FOR STUDYING THE PROCESS OF LEARNING, MEMORY AND VISUAL LITERACY[1]

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One of the most important characteristics of human behavior is the quality of change. Those who use the scientific method to account for human behavior center upon the phenomena of behavioral change, and more specifically on change in behavior capabilities. Sometimes, behavioral changes are studied with respect to specific forms of behaviors, usually over relatively limited periods of time. The researcher, in such instances, calls the processes he studies Learning and Memory. Another major class of phenomena of behavioral change comprises general classes of behavior observed over longer periods of time -- months and years. The latter set of events is usually attributed to a process called development (Gagné, 1968).

Gagné (1968) stated that the reality of the products of learning and development is obvious in every day experience and requires no special experimentation to verify. The capabilities of the young child, for example, change before our eyes daily, as he learns new motor and perceptual skills, new names for the already familiar things, and new facts. From daily records of common observations it is possible to distinguish between the specific short-term change called learning and the more general and long-term change called development.

What is the nature of the relation between learning and development? Within limitations imposed by development, behavioral development results from the cumulative effects of learning (Gagné, 1968). "The child progresses from one point to the next in his development, not because he

acquires one or a dozen new associations, but because he learns an ordered set of capabilities which build upon each other in progressive fashion through the processes of differentiation, recall, and transfer of learning (Gagné, 1968, p. 181)." Each of the three phenomena of behavioral change, viz., learning, memory and development are necessary for the acquisition of literacy in the visual area. Discussion of all of these processes would require extensive space and time and the limitations of the present paper would not permit justice to be done to the discussion of each of these three important areas. Hence, this presentation will focus on visual literacy as it is influenced through the process of learning and primarily it will discuss the methodologies essential to study the nine propositions proposed by Williams (1970). The authors are of the opinion that the acquisitions brought about by the process of learning are manifest only through recall or recognition.

It is essential to note that memory models would play a very significant role in determining the adequate methodological strategies for investigating visual literacy and an attempt will be made here to present some of the relevant and emperically tested models. No specific learning models will be discussed in the present paper but we are subscribing to the notion that behavioral development results from the cumulative effects of learning and that these effects can only be ascertained by testing the extent of short- or long-term memory.

Models of Memory

The nature of human memory has continued to baffle investigators. There are many issues that researchers have been concerned with, e.g., whether there is a single storage system or a multiple one, the nature of the processing of information that takes place, the invariant

features of the memory processes, the role of the individual in the storage of information, the nature of the stored information, etc. Kumar (1971), in an excellent review article, pointed out how an understanding of these issues could aid educators in creating better learning environments.

Most contemporary investigators assume that there are three different types of memory systems: A sensory storage or register (SR), a short-term store (STM or STS), and a long-term store (LTM or LTS). The existence of the SR is a well-documented phenomenon (Neisser, 1967; Norman, 1970). Even Melton (1963b), a strong proponent of a single storage system, stated: "It seems to me necessary to accept the notion that stimuli may effect the sensorium for a brief period of time .... (p. 4)."

The major controversy rests in the distinction of the STM and the LTM as two separate systems (Keppel, 1968; Norman, 1970). Are the STM and the LTM two dichotomous mechanisms or are they two different points on a recall continuum with the difference arbitrarily related to the length of the retention interval (Melton, 1963a, 1963b). Many contemporary researchers who prefer the dichotomy think of the various systems "As some sort of boxes in the head or different storage compartments with mnemonic information being transferred from one compartment to another (Tulving & Madigan, 1970, p. 440)."

Although the available evidence is not as definitive as one would wish, the weight of the evidence supports the distinction between STM and LTM (Kintsch, 1970). The existence of the STM and LTM as two separate systems are justified on the basis of durability of storage, forgetting, form of trace, effect of repetition, effect of rate of presentation and spacing, capacity, physiological evidence, etc. From the preponderance of the evidence available, it is clear that

until further evidence is available on this issue, the assumption of a multiple store system model of memory comprised of the SR, the STM and the LTM is reasonable.

Incoming information is first registered on an extremely labile memory called the SR. The SR is considered as part of the storage system rather than a mere registering mechanism, since information persists there for sometime before it decays. The storage in SR could be in any sense modality: visual, auditory, olfactory, tactile, and kinesthetic. Although some work has been done on the auditory store (Neisser, 1967), Atkinson and Shiffrin (1968) commented that a registration mechanism comparable to the visual system had not yet been isolated in other sense modalities. Furthermore, the evidence obtained from investigations on visual modality cannot be generalized to other systems because of the possible different structural aspects. Hence, it is important to discuss the structural properties of the visual SR, termed the Iconic Store (IS) by Neisser (1967), and the transfer process of information from this store into the other memory systems. This discussion will become the frame of reference for the search for strategies of research in visual literacy.

Iconic memory is the persistence of visual impression for a short period of time after the stimulus has been terminated (Neisser, 1967). The visual input is, in other words, stored briefly in a medium and the information from this medium can be read as if the stimulus was still active. Evidence of the IS is available from experiments by Sperling (1960), Averbach and Coriell (1961), and several other investigations using a tachistoscope to present their stimuli. Evidence is also available from reaction time (RT) studies such as that of Posner and Mitchell (1967), which showed that matching pairs of letters whose

physical and nominal characteristics are identical (such as "b" and "B") was faster than matching pairs whose nominal characteristics alone are identical (e.g. "B" and "b").

A number of characteristics of IS are enumerated below.

1. Information in the IS is believed to be represented in terms of its physical characteristics (Neisser, 1967) or in a photograph-like form (Atkinson & Shiffrin, 1968).

2. The duration of the icon has been estimated from tachistoscopic studies to be several hundred miliseconds (Atkinson & Shiffrin, 1968; Neisser, 1967) before it decays. The icon is also a function of the total energy available which in turn is a product of intensity of illumination and the duration of exposure of the stimulus (Kahneman & Norman, 1964).

3. The capacity of IS is much larger than the STS. The IS information, however, decays very rapidly.

4. Forgetting from IS occurs in two ways: (a) rapid decay and (b) masking. Rapid decay of the trace is simply a decrease in accuracy of report, as the unfilled interval lengthens (Averbach & Sperling, 1961; Sperling, 1960).

5. It appears that if no processing of the stimulus has been done, it is likely that the errors will have structural features similar to the correct items. If the items have entered STM, then the likelihood of acoustic errors increases.

6. As the image in the IS is assumed not to enter the nervous system or the central processing system, repetition should have no effects. Glucksberg & Balagura (1965) found no effect of repetition even with five hundred repetitions.

Information Flow from SR to Other Systems

The information flow between the memory systems is referred to as "transfer". Atkinson and Shiffrin (1968) described this as "copying of selected information from one store into the next (p. 94)." This copying is believed to take place without the transferred information being removed from the original store. The various directions of information flow from SR are shown in Figure 1. The basic process

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Insert Figure 1 about here

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responsible for the transfer of information seems to be the feature extraction (Norman, 1970) or scanning (Sperling, 1967; Atkinson & Shiffrin, 1968) of features by some form of stimulus analysis mechanisms. Stimulus analysis mechanisms extract the features and present them to the naming system. The naming of the features takes place against the information stored in the LTM and this is then fed into the STM. Along with the name, other information about the stimuli could also be recovered such as the color, taste, smell, associations, etc. (Atkinson & Shiffrin, 1968).

The controversy between sequential and parallel transfer of SR information into other memory systems is unresolved. According to Sperling's (1960, 1963, 1967) work, it appears that transfer takes place sequentially. However, Wheeler (1970) argued that the parallel or serial controversy needs to be stated in terms of the perceptual unit. He proposed a two-stage model -- the first stage is the feature extraction stage in which processing is presumably parallel, and the second stage uses the features to find, construct, or determine a code for the stimulus. Beller's (1970) RT study supported the above notions. These findings

support the models of pattern recognition proposed by Selfridge (1959) and Neisser (1967). Feature extraction first takes place by the pre-attentive low level analyzers which are error prone, fast, parallel, and require no contact with past experience. Once the features have been extracted, the more discriminative focal attentive analyzers act on the features. These latter analyzers are slow, serial, and require the help of LTM. It must be pointed out, however, that this controversy is far from being resolved at the present time. Conflicting evidence is forthcoming and until conclusive evidence is obtained the nature of transfer is an unresolved issue of interest to researchers in this area.

Whatever process is used for the transfer of information from SR to other memory stores, it is interesting to speculate as to what gets transferred. It appears that the information transferred into STM and LTM from the SR depends largely on the individual. Atkinson & Shiffrin (1968) described the set of processes which are under the control of S as "control processes." Selective attention is one such process, for example.

During the transfer process of SR to STM, transformation of the input information results. Several studies exist which suggest that the transformation of the visually or orally presented stimuli into some verbal or acoustic form occurs within one second after presentation (Sperling, 1967; Sperling & Speelman, 1970). Glanzer and Clark (1963) first postulated the verbal loop hypothesis. They stated that first the visual information is translated into a series of words and second the subject stores the verbalization which becomes his basis for a final response. They found that brevity of verbal description was highly correlated with the reproductive recall of trace of simple black and white figures.

Very little emphasis was made in any of the above studies on the existence of a visual STM. Evidence, however, is accumulating in favor of a visual STS. Posner and Konick (1966) compared retention functions for a visual location task and a kinesthetic distance task. They found that Ss relied on visual and kinesthetic memory codes in addition to verbal labels. In a later study, Posner (1967) noted that some rehearsal of visual STS occurs but it is mainly a function of the availability of the central processing capacity which could be disrupted by an interpolated activity. Among many studies of this nature Randhawa (1971, 1972) in a developmental study for visual and verbal tasks established visual STM. Randhawa (in press) also found that the nature of transformation is dependent upon the complexity of task in experiments involving perceptual word, and sentence stimuli presented visually under recognition and recall conditions.

Visual STM does seem to exist, but it seems to be used less than the auditory or verbal STS, probably because it is a slow process and more fatiguing. In the studies reported on the verbal loop hypothesis, Ss used were adults and students in the university. The choice of Ss may account for the difficulty in finding evidence for a visual STS.

The transfer of information from STS to LTS is heavily dependent on the control processes excersised by the S, namely rehearsal and coding (Atkinson & Shiffrin, 1968). Their findings suggested that it was entirely up to the subject whether he used one or the other or even both of these processes. Adoption of rehearsal or coding technique perhaps depends on the existing knowledge in LTS. With more existing knowledge about incoming information, there would be less tendency on the part of the S to engage in rehearsal.

Guilford (1966), however, proposed a model for problem solving.

This model is given in Figure 2. It is clear from the examination of

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Insert Figure 2 about here

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this model that for various perception or information processing situations, this model could provide an adequate frame of reference for understanding the various processes involved in problem solving tasks. This model could also take care of the sequential or simultaneous information extraction controversy for transfer from SR to the STM. As well, Guilford's model can adequately explain the various other mechanisms involved in transfer from STS to LTS and the underlying analyzing processes adequately. Researchers must be directed to apply this model and a synthesis found in psychological theory to answer the question of the nature of information transformation for STM and LTM for several stimuli.

Nine Ammendments and Methodological Critique

Williams (1970) advanced nine visual literacy propositions and provided evidence for each of these from the existing literature. Each of the Williams' propositions will be examined in the light of the supporting evidence and appropriate research methodologies will be proposed for investigating them.

Proposition 1: "An impoverished environment leads to delayed or inadequate development in spite of adequate hereditary potentialities." Williams (1970) cites Soares and Soares (1969) and Provence and Lipton (1963) as evidence for this statement. On examining Soares and Soares (1969) it is evident that this study in no way supports the assumption nor does it support the tentative conclusion arrived at by Williams. Similarily, the Provence and Lipton (1963) study in no way

leads one to conclude that impoverished environments do in deed result in visual problems in the later life of the organisms. It appears to us that investigation of this proposition is possible only if a controlled experimental study is carried out in which the criterion variable is a visual perception task. There are several problems associated with an investigation of this kind. One such problem is that of depriving Ss in the control group of early visual experiences in order to conclude, on the basis of comparison with the experimental group, that visual deficits in early life result in visual problems in later life. There are, however, a number of classic illustrations in psychology which lend some indirect support to this proposition. These classic illustrations are suspect in the sense that no control situation is possible and the results, therefore, have limited reliability and generalizability. The context in such investigations has to be properly evaluated before a firm conclusion is reached.

Logistically, however, it is reasonable to expect that early deprivation of visual experiences would result in visual problems in the later life of the organisms concerned. But logic or logicstics may not be the guide in scientific experimental search for the truth.

Proposition 2: "Visual enrichment in early life appears to make an organism more successful in visual tasks in later life." The supporting evidence for this proposition was an animal study (Gibson & Walk, 1956). Two other studies involving humans were also quoted in support of this proposition (Dodd & Barabasz, 1968; Geber, 1958). On examination of these studies, it would appear that Williams extrapolated his proposition from them even though there was no specific evidence available to verify the proposed proposition. This proposition, like Proposition 1, requires, again, an experimental design with specific

controls in order to conclude the effect of visual enrichment in early life on later visual competency.

Proposition 3: "It is proabable that a program of visual enrichment can improve learning if effectively implemented." The supporting study (Raven & Strubing, 1968) found that training on directly related visual materials and training on indirectly related visual materials significantly improved learning on a science unit. The conclusion drawn from this study by Williams (1970), that a program of visual enrichment improves learning, is, however, a dubious one when it is realised that transfer of training could just as adequately account for the obtained effect. Furthermore, it is necessary to operationally define "effective implementation of a program of visual enrichment to bring about improvement in learning." This operationalizing would require quantification of implemented programs and research would need to be directed towards training prople visually, determining the effect on the trained groups as opposed to the groups not provided training on visual tasks, and subsequently comparing the results of these groups on a pre- and post-test for different learning situations. The different learning tasks could range from those involving visual experiences to those which may be least affected by visual training, such as strictly verbal tasks. This would enable the researchers to determine the extension of enrichment programs in visual literacy on the consequent learning in other learning situations.

Proposition 4: "The ability to sequence visual stimuli is related to the experiences (history) and opportunities provided for the learner." This is an interesting proposition and it seems to involve individual cognitive styles and environmental interaction with these individual

styles. It appears that Williams (1970) did not find any substantive evidence supporting this proposition. However, he arrived at a general tentative conclusion which was based on Strandberg and Griffith (1968) study, namely, that the training in sequencing does have an effect on the length and complexity of the language the child uses to describe his pictures. This study does not substantiate the proposition per se. It does indicate, however, the consequent effect of training on the production of language by children undergoing training in sequencing. This proposition also seems to relate to the selective attention of children and adults in perceptual and other tasks. In free response situations, given a sequencing task, the individuals would be expected to sequence the set on the basis of selected attributes. An appropriate paradigm for this proposition would be the presentation of specific stimuli based on multiple dimensions (known or fixed) and requiring the Ss to sequence them in a free response situation. Multidimensional scaling techniques involving an individual differences model like the one proposed by Tucker and Messick (1963) would provide an insight into the underlying individual differences in selective attention and cognitive styles. These individual differences could then be related to production of language.

Proposition 5: "Development of 'Glance-Curve' is related to sequencing experiences and early reading related experiences." This is a problem in perception that has to do with the differences noted by observers in spatial and other properties of objects appearing at various positions in the visual field, particularly in one lateral half versus the other. Gaffron's (1950) theoretical account explains the differing efficacy of the right and left halves of viewed scenes,

particularly in art situations. This theory is the extrapolatory basis of the present proposition. Gaffron proposed the "Glance-Curve" to account for an empirically demonstrated asymmetry of perceptions in the right and left fields of viewed scenes. This curve describes two things in particular: 1. The observer orients himself in a particular position with reference to the scene or target viewed. The observer treats the scene he views as if he placed himself in a position so as to obliquely regard it from the left, and; 2. The observer, in effect, looks first into the foreground and progresses from there obliquely into the middle and background and then somewhat to the right.

Since Gaffron's research was done on the subjects who were brought up in the Western world, it is reasonable to assume that reading related experiences result in the development of particular glance habits. It appears likely, therefore, that research done on samples from various cultural groups and particularly, subjects whose reading-related experiences are such that they are different from the reading related experiences in the Western world, e.g., subjects whose early reading experiences are in Urdu or Persian, etc. and the use of precise measurements or measuring instruments such as those of occulometers in this kind of research will further add precision and reliability in the results obtained.

Proposition 6: "Hierarchical potential in pictorial scene or set of pictures is related to organisms history, sequencing ability and development of verbal literacy." This proposition, the way it is stated, is highly loaded. It needs to be broken down into various components for research purposes. Investigators need to examine in turn the relationship between hierarchical potential

with each of 1. organisms history, 2. sequential ability of organisms, and 3. development of verbal literacy. It becomes necessary, therefore, to measure the associated variables and find the respective measures of association under the limitations of the scales of measurement employed to measure these variables. However, if the interest is to examine the association of all the related variables together with the hierarchical potential, multiple correlation may also be considered.

Proposition 7: "The development of the ability to engage in visual metaphoric communications and activities is related to the development of verbal literacy." The investigation of this proposition would require a correlational model. The measurement of verbal literacy and the extent of visual metaphoric communications and activities would need to be operationalized. These constructs should be carefully defined and the instruments devised to measure these constructs validated. The obtained relationship would reflect the extent of association between these constructs as measured by the instruments used. However, it is possible to use existing instruments if they fit the definition of these constructs.

For the reliability and generalizability of results it would be desirable to use different age groups and show in all instances the same kind of association of relationship. If a causal relationship ought to be determined, then the question needs to be restated in terms of a causal hypothesis.

Proposition 8: "There exists a range of visual literacy sophistication and this range is related to history and opportunities." Williams (1970) further states "These characteristics of the visually sophisticated are not ranged in any order. All that can be said at this point is if an individual is visually sophisticated, he may have

a number of these characteristics." This proposition emphasizes the individual differences model and the model can be demonstrated in several ways. The individual characteristics could be determined in terms of a direct measurement of the characteristics concerned. In an alternative research strategy, it would be possible, however, to determine the dimensionality of the space spanned by the history of the individuals in the sample and the extent of visual literacy sophistication. The input data for investigation of this proposition could be construed to be correlations between the history and opportunities (environmental variables?) and the extent of various measures on visual literacy sophisitication. It would also be possible to set up an experimental design where the subjects were classified on the basis of the history and opportunities and where the extent of the visual literacy sophistication was measured on various characteristics. The most appropriate model for this kind of experimental design would be a multivariate analysis of variance one, followed by individual analyses on the various characteristics. The design could also go beyond the analysis of variance and set up discriminant functions if the researcher has interest in knowing the discriminant axes for the various groups.

Proposition 9: "The ability to transfer back and forth between visual-visual metaphors, verbal-visual, visual-verbal, and verbal-verbal metaphors is related to visual and verbal literacy development." This proposition seems to be ambiguous as it is stated. In a restatement we would delete the words back and forth. Alternatively, this proposition could be stated in terms of an information processing model and the rewording would become "The ability to process visual-visual, verbal-visual, visual-verbal, and verbal-verbal information is related

to visual and verbal literacy development." The first component in each set is the stimulus mode or the input mode and the second component is the output mode or the response mode. In various experimental studies involving stimuli of various kinds, it appears that development plays a major role in information processing tasks. Randhawa (1969, 1971, 1972, in press) examined these propositions and has demonstrated developmental trends and interesting input and output mode interactions. Randhawa used stimuli of various complexities and employed multivariate analytic techniques to analyse the data in the various studies. Randhawa (in press) found that the complexity of the stimuli determines the mode of storage of information before output is made.

Summary

This paper dealt briefly with the memory models and the transfer mechanisms from sensory register to short-term memory and long-term memory. The position taken by the present paper was that the process of development is an accumulative process of learning and that learning and memory are the resultant of acquisition of new knowledge, sensations, etc. over a short period of time.

Williams' (1970) nine propositions were examined and recommendations made for investigating them. The area of visual literacy is an exciting area for researchers. Research efforts should provide evidence of the efficacy of visual literacy so that appropriate teaching methodologies to facilitate visual literacy can be acquired. The value of various audio-visual, particularly visual, explanations as they improve learning on tangible criteria need to be determined. It would seem that visual literacy is a catch-can term which means many things to many people. Until researchers clearly decide what they mean by this term, the authors of this paper feel that much

time will be wasted trying to relate already well documented areas which may or may not be relevant. The time has come for researchers to zero in on a clear, well operationally defined area of research calling itself visual literacy. If visual literacy exists only in terms of perception, language development, semantics, learning, human development, etc., as Williams (1970) suggests, why coin another word to confuse the issue?

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Footnote

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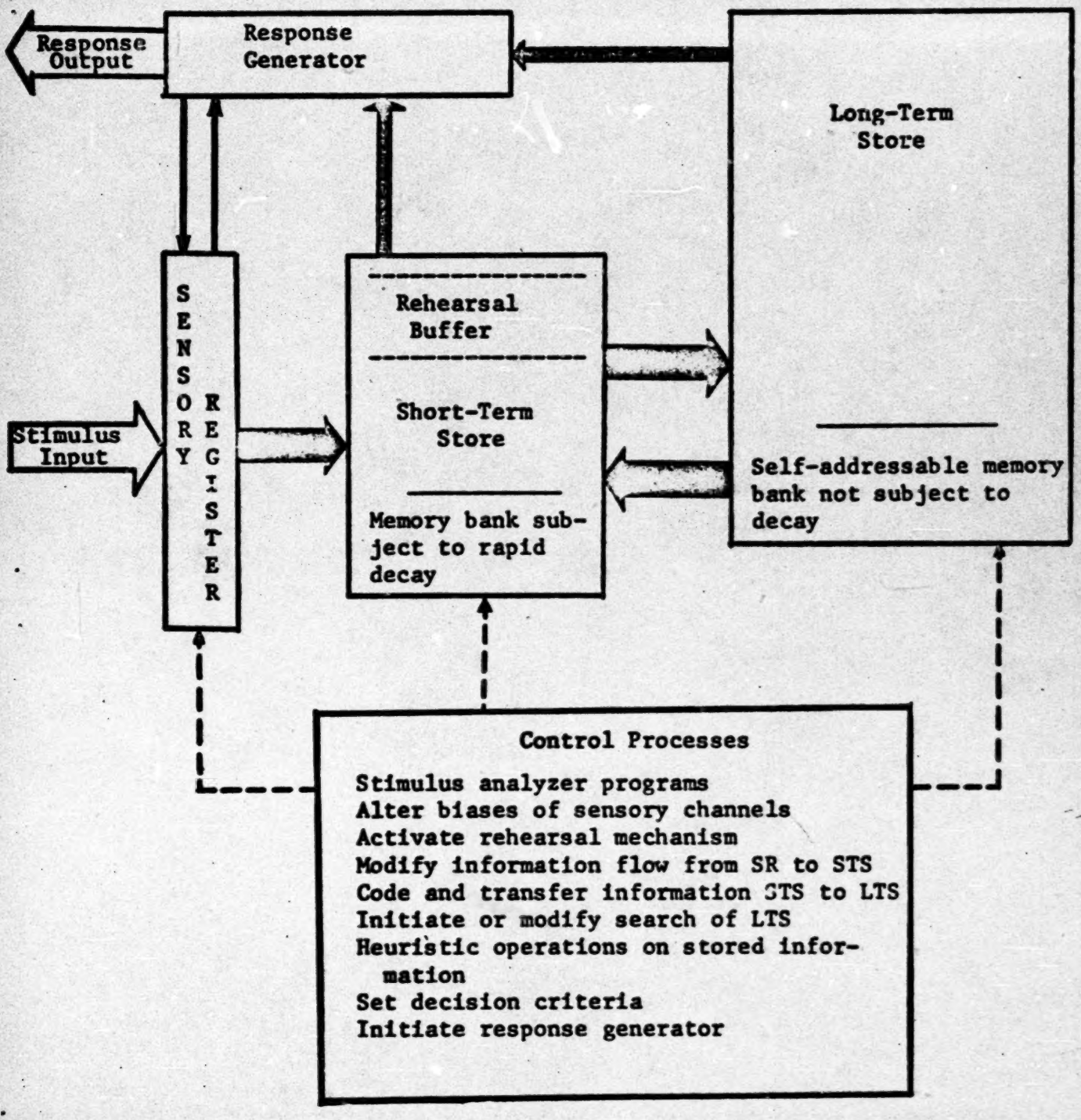

Fig. 1. A flow chart of the memory system (Shiffrin & Atkinson, 1969)

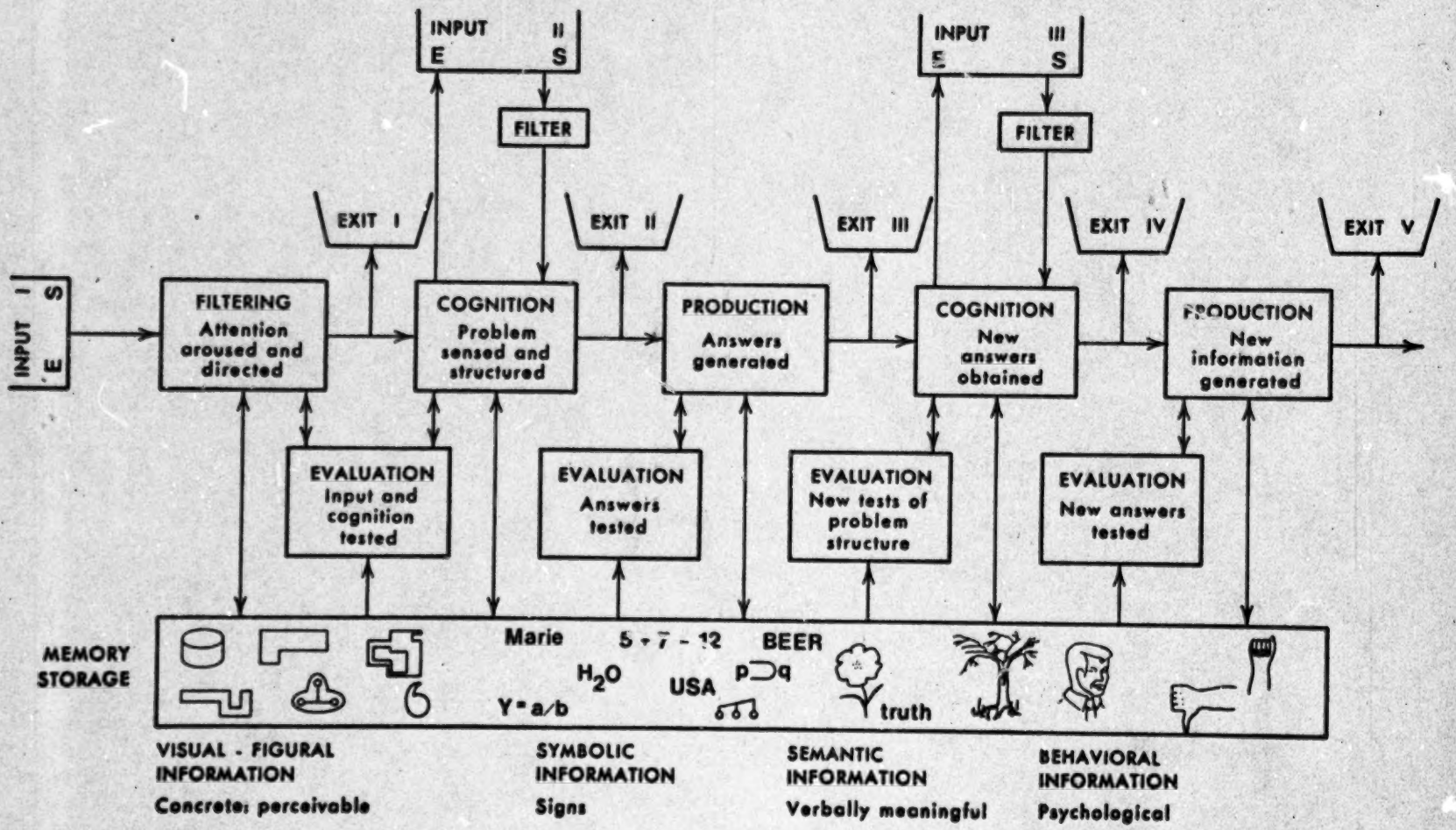

Fig. 2 Model for problem solving (Guilford, 1966)